

ORIGINAL ARTICLES

RECENT ADVANCES IN REGIONAL
(LOCAL) ANESTHESIA.*

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If ever there was an instance of the development of a fertile and far-reaching field from the seed of an apparently unimportant technical detail it is that of the development of regional anesthesia from Braun's discovery of the combination of adrenalin with cocain and other local anesthetics in 1902. Before this the application of local anesthesia was exceedingly limited, and how inadequate it was all of us who have seen the old "infiltration-anesthesias" of Schleich can bear witness. The great absorbability of pure solutions of cocain, eucaïn, novocain and other similar drugs was the stumbling-block that impeded their use for more than the anesthetization of certain very limited fields.

The anesthetic effect of these drugs is due to their property of temporarily inhibiting the conduction along the course of a nerve of those stimuli that we feel as pain, or of temporarily paralyzing the receptors of these stimuli, the terminal filaments. In order to accomplish this it is necessary that a sufficiently strong solution of the drug remain in contact with the nerve or the filament to be paralyzed for a sufficiently long time. It is impossible to block a nerve by injecting a pure solution of cocain into the surrounding tissues unless we inject it in a concentration strong enough to be dangerously toxic, and this simply because the drug is carried away into the general circulation before it has time to penetrate the nerve-trunk around which it is injected. It diffuses into the loose cellular tissues around the nerves with a much greater rapidity than it pervades the relatively firm structure of the nerve itself, and it is for this reason that the absorbability of the anesthetic solutions proved such an impediment to their extensive application. So that before this discovery of Braun's, before the discovery of the addition of a vaso-constrictant to the anesthetizing solution, the successful application of local anesthesia was limited firstly, to those tissues whose mechanical texture made the solution difficult of absorption—such as the tough layer of the corium, anesthetizable by the intradermatic method of Schleich; and secondly, to those regions that admit of the application of mechanical devices to hold the solution in place—such as the digits and the penis, which Oberst anesthetized with the aid of a constricting rubber band. These were the very limited fields of successful and dangerless local anesthesia before the date of Braun's discovery; attempts at a true nerve-blocking, at a regional or conduction-anesthesia by injections through the skin had not led to practicable results.

The older workers with local anesthesia were fully cognizant of the fact that it was the absorbability of their solutions that stood in the way of their wider application; as far back as 1885 Corn-

ing of New York described methods of local anesthesia with cocain, in which he prevented the absorption of the drug by means of Esmarch bandages, compression forceps, rubber-covered rings of wire and similar devices. Crile sought to limit the quantity of cocain by laying the nerve bare under general or infiltration-anesthesia and then making an injection into the nerve-sheath itself.

But this difficulty, the difficulty of getting the solutions to stay where they were wanted, was not the only one with which the earlier workers in this field had to contend; the absorbability of their solutions was made still more pernicious by the high toxicity of the drugs they had at their disposal. I need not allude to the deaths that have occurred from the absorption of very small doses of cocain in patients showing a peculiar susceptibility to this drug, nor finally call attention to a further deficiency—to the fact that it decomposes at 98° C. so that it cannot be sterilized by boiling.

The discovery of novocain by Einhorn was a great step forward; this drug has completely supplanted cocain in regional anesthesia; its anesthetic power is high, a 0.1% solution sufficing to produce anesthesia at the site of injection, it is absolutely non-irritating even in a 10% solution, its solutions may be sterilized by boiling for a short time without decomposing the drug, and most important of all—its toxicity is very low. Liebl injected $\frac{3}{4}$ gramme into himself without any ill effects, more than 2 grammes have repeatedly been injected without harm to the patient, a death from novocain as far as I know has not been recorded. I have never even seen a serious collapse from its use. It is the hydrochloric acid salt of the novocain base that is usually employed; Gros, however, found that we may double or treble the anesthetic power of the drug by using a bicarbonate salt. He has given several formulas, the following is the formula for the 1% solution:

Sodii Bicarb. puriss. pro analysi (Merck)	0.25
Sodii chloridi	0.50
Novocaini hydrochloridi	1.00

This powder if kept dry does not deteriorate; when ready for use it is dissolved in 100 cc. of cold sterile distilled water, sterilized by boiling up rapidly and cooled quickly under a jet of water; 10 drops 0.1% adrenalin are then added. When the solution is boiled a certain amount of CO₂ is given off, some of the bicarbonate being reduced to the alkaline carbonate, and the anesthetic power of the mixture is increased. This salt of novocain is therefore rendered more active by sterilization, it has a greater anesthetic power than the hydrochloric acid salt, anesthesia follows its injection more rapidly and is more abiding than with the hydrochloride. Its use is of especial advantage in the blocking of thick nerve-trunks, such as the sciatic, which are enclosed in a resistant sheath and are very hard to anesthetize by the ordinary perineural injections.

By these two discoveries: Braun's of the addition of adrenalin to the anesthetizing solution, and Einhorn's, of novocain, have the absorbability and the toxicity of the anesthetizing solutions been overcome, the stumbling blocks to local anesthesia removed and the recent development of regional an-

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esthesia made possible. With a relatively non-toxic sterilizable drug in our hands, and with the help of adrenalin we can effectively block the sensation of pain along the thickest nerve-trunks and the application of regional anesthesia has been extended until its limits have been set only by the anatomical conditions met with in the various regions of the body.

In general we may state that all those parts of the body are amenable to regional anesthesia which are subserved by one nerve or by a simple combination of nerves, the anatomical position of whose course admits of their being reached by the anesthetizing needle without damage to important adjacent structures.

Regional anesthesia has come to be merely a matter of the anatomy of the peripheral nerves—given a part of the body of simple innervation, find the point at which its nerves can be most effectively blocked. It is along these lines that the limits of the application of regional anesthesia have been extended of late. Recent years have brought no new fundamental principles; it is some of the results of recent anatomical work that I should like to detail to you to-night. I shall not repeat what Braun has already laid down in his classical monograph, but shall confine myself to the territory gained for local anesthesia since his last edition of 1907, correlating the experience of others with my own where I can.

THE HEAD.

The gain of the territory of the mouth, chin and jaws for regional anesthesia is to my mind

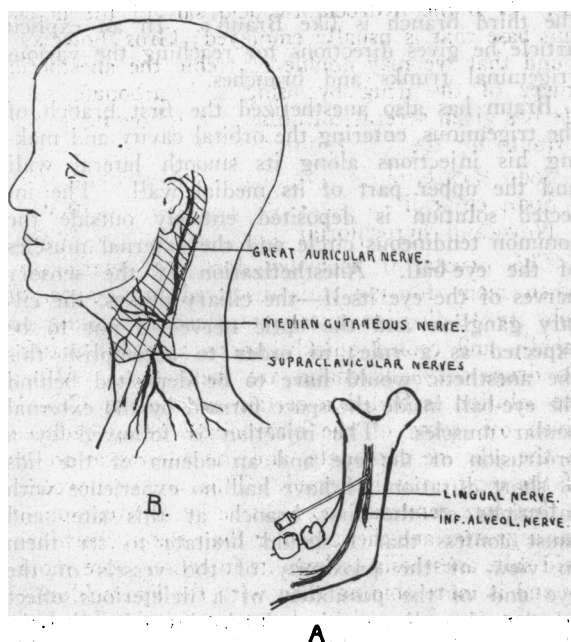


Fig. 1 (A) Position of needle for blocking third branch of trigeminal at the jaw.
Fig. 1 (B) Area of anesthesia after injection at posterior border of sterno-cleido-mastoid.

the most important advance in the surgery of this region that has been made for many years. By operating under regional anesthesia the risk of post-operative bronchopneumonia is very much lessened, the sense of security and the ease afforded

the operator by having a patient who can clear his throat and open his jaws is very great, and hemorrhage, owing to the constriction of the vessels by the adrenalin is reduced to an easily controllable degree, rendering such measures as temporary ligation or compression of the carotid unnecessary. The picture of the constant struggle between anesthetist and operator, both working in a field drenched with ether fumes, of the half-awake, struggling patient, kept between cyanosis and aspiration of blood on the one hand and consciousness on the other, will soon, I think, be a thing of the past.

I wonder that the blocking of the alveolar nerves for extensive operations on the teeth and jaws has not been more extensively practised. I shall overstep the limits I set for this paper by describing it, as it is already explained by Braun in his last edition, but I should like to urge it upon your attention. The upper teeth, including pulpa and peridental membrane, the alveolar process of the upper jaw and the buccal mucosa of the upper gums are innervated by the superior alveolar nerves from the second trigeminal. The oral mucosa of the gums and the palate are innervated by the palatine nerves and by the naso-palatine nerve of Scarpa, also from the second trigeminal. Thus we may anesthetize the whole upper alveolar process by anesthetizing the second branch after it leaves the round foramen. This is a somewhat difficult procedure, necessitating considerable practice. I shall refer to it later. A much simpler method, sufficient for the surgery of the roof of the mouth, is the separate blocking of the superior alveolar, the palatine, and the naso-palatine nerves. The superior alveolar nerves may be reached by a submucous injection parallel to the teeth, beginning in the middle line 1 cm. above the edge of the gums and proceeding backwards as far as the tuberosity of the maxilla, where these nerves lie directly beneath the mucosa. The branches for the front teeth do not lie submucously, but are separated from the anesthetizing solution by a very thin lamella of bone through which the solution diffuses in about 3 to 10 minutes. The posterior palatine nerves are blocked by an injection at the posterior part of the hard palate, the naso-palatine by an injection near the middle line; a few drops of novocain-adrenalin suffice. In this way the whole superior alveolar process and the palate may be rendered anesthetic.

Anesthesia of the mandible is more simple. The third branch of the fifth may be reached before its division into lingual and inferior alveolar nerves by an injection along the inner surface of the lower jaw, beginning 1 cm. behind and lateral to the last molar, and proceeding along the bone for 2-3 cm. This one deposit anesthetizes mandible, anterior portion of the tongue, mucosa of the mouth and middle part of the lower lip. For operations involving the chin it is further necessary to block the superior and median cervical nerves by a subcutaneous injection below the jaw. If we change the direction of this latter injection and deposit our solution along the posterior border of the sterno-cleido-mastoid muscle we can block the cervical

nerves as they emerge from behind this muscle and anesthetize a much greater area of neck and chin. These two deposits of novocain therefore, at the inner surface of the mandible and along the posterior border of the sterno-cleido-mastoid will give us an anesthesia of the lower jaw, the anterior portion of the mouth, including two-thirds of the tongue, the lower lip, the chin, the submaxillary fossa, and the upper cervical triangle. A supplementary subcutaneous injection below will give us the upper part of the neck and all that we need for a radical operation for cancer of the lip, with block-dissection of the glands, and if necessary, resection of the jaw.

A very extensive field is gained by direct injection of the trigeminal nerve-trunks at the base of the skull. These procedures are not easy and necessitate considerable practice on the cadaver, but their brilliant possibilities fully repay the difficulties encountered in acquiring their technic. As long ago as 1900, Matas reported the anesthetization of the second branch for resection of the upper jaw; alcohol injections of the trigeminal branches at the base of the skull for neuralgia, have been employed by Schlösser, Ostwald, Harris, Patrick and others for a number of years, but it is only within the last year that communications have appeared concerning systematic nerve-blocking with local anesthetics at these points. A careful anatomical study by Offerhaus of Groningen gives useful data. He finds that the distance between the outer sides of the superior alveolar process at the last molars is exactly equal to the distance between the two oval foramina, and that the distance between the inner sides of the superior alveolar process at the last molars is equal to the distance between the round foramina. The inter-alveolar distances are readily measured in the living with a pair of calipers. The foramina rotunda lie a few millimeters behind and above a line drawn between the middle of the zygomata. If, therefore, we insert a needle directly under the zygoma at its middle point and introduce it for a depth equal to one-half the interzygomatous distance minus one-half the internal interalveolar distance, directing the point very slightly upwards and backwards, we will by mathematical calculation reach the second branch of the trigeminus at its exit from the round foramen. The patient's jaw should be open while introducing the needle. If the needle is properly directed a sharp pain will be felt when the nerve is reached; 5 cc. of a 1 to 2% solution of novocain-adrenalin should now be injected, then the needle withdrawn and a second 5 cc. be injected while the needle traverses the pterygoid musculature. The latter 5 cc. are not for purposes of anesthesia, but are injected so that the adrenalin content of the solution may cause a contraction of the internal maxillary artery and secure a field of operation comparatively bloodless.

The third branch may be reached by a similarly calculated injection. The oval foramina lie in a line joining the two articulatory processes of the tempero-sphenoid bones; the distance between them is equal to the external alveolar distance. The distance of the oval foramina from the surface of the

skin is therefore equal to one-half the inter-tubercular distance minus one-half the external inter-alveolar distance. After this measurement is determined it is marked off on the needle, which is inserted just anterior to the articulation of the jaw and is introduced perpendicularly up to the point marked off. Offerhaus has constructed a special calipers with perpendicular wings that serve as guides to prevent the needle deviating from its proper course. The mathematical calculations followed by Offerhaus may be substituted by practice and experience, Braun deems them unnecessary. He guides his needle by the sense of touch, as do Schlösser, Ostwald, Harris and others who inject these trunks with alcohol in trigeminal neuralgia. Patrick, in a recent communication even considers the calculations misleading, and has found them to deviate considerably from the true measurements in certain types of skulls. Braun reaches the second branch in the pterygo-palatine fossa, feeling his way along the tuber maxillare; when the fossa is reached the needle suddenly slips forward and a sharp pain is felt in the face and cheek, a signal that the needle has touched the nerve-trunk. As a guide to the third branch he uses the pterygoid fossa, when the needle meets bony resistance at this place the point is withdrawn and its direction projected about 1 cm. farther backwards, it is then pushed forward to the original depth, corresponding to the distance of the pterygoid fossa from the surface of the skin; the foramen ovale lies at this point. Patrick uses the external pterygoid plate as a guide to the second branch; he feels his way around its anterior edge; his technic for the third branch is like Braun's. In an explicit article he gives directions for reaching the various trigeminal trunks and branches.

Braun has also anesthetized the first branch of the trigeminus, entering the orbital cavity and making his injections along its smooth lateral wall and the upper part of its medial wall. The injected solution is deposited entirely outside the common tendinous circle and the external muscles of the eye-ball. Anesthetization of the sensory nerves of the eye itself—the ciliary nerves, the ciliary ganglion and the optic nerve—is not to be expected as a rule; in order to accomplish this the anesthetic would have to be deposited behind the eye-ball inside the space formed by the external ocular muscles. The injection is followed by a protrusion of the eye and an edema of the lids of short duration. I have had no experience with injections of the first branch at this site, and must confess that I should hesitate to try them in view of the proximity of the vessels of the eye and of the possibility of a deleterious effect of the adrenalin-anemia. Enthusiasm for the elegance of the methods of local anesthesia is liable to carry one versed in its use too far. I do not think that we should lose sight of the fact that the risk of an ether narcosis would be gladly accepted by most patients when weighed against any possibility of danger to the eye. I should be inclined to wait until some sober and experienced observer can report a considerable series of cases without mishap, and barring a very urgent indica-

tion against ether, should attempt the intraorbital blocking of the first branch only in a case where the eye was already permanently damaged.

In making our plans for blocking the nerves of the head we should be guided by the innervation of the bony parts involved in the proposed operation. The first branch serves orbit, its contents and the neighboring sinuses. The nose and its dependent sinuses are served by the ethmoidal nerves from the first branch and also by the second branch; antrum of Highmore, whole upper jaw and both palates are innervated by the second branch alone. The third branch serves the lower jaw, the floor of the mouth, and the anterior two-thirds of the tongue. It is the cavities of the head that we have to consider in planning our sites of injection, the soft parts of the face are of no moment; they should always be blocked separately, in order to produce an adrenalin-anemia, and in order to make their anesthesia more complete.

Regional anesthesia is destined, in my opinion, to rob the surgery of the mouth and pharynx of its horrors. Who is there of us, who, laying aside the needle of the last suture after an extensive operation for cancer of the tongue, dazed by the fumes of ether, tired after an arduous struggle with hemorrhage and with a choking patient, has not stood and looked with trepidation on the result of his labors—has not felt that the fight was but begun, thoughts of aspiration-pneumonia menacing his ease and robbing him of the pleasure of a well-done task?

In eight resections of the maxilla under regional anesthesia, Braun had not a single post-operative pneumonia, in twelve patients operated upon for various cancers of the oral cavity he had two pulmonary complications, in these twenty cases a post-operative mortality of nil!—contrast this with the usual mortality of from 15 to 20%.

I hope that I have not unduly trespassed upon your attention by my dilation on the regional anesthesia of the head; it is true that explanations and words are of little avail here, a glance at Braun's photographs or the witnessing of one operation will do more towards converting you from general narcosis for operations on the head and jaws than the most plausible arguments, an hour's work on the cadaver more towards acquiring the technic than the most extensive theoretical deliberations.

THE NECK.

Recent years have added nothing of fundamental importance to our knowledge of regional anesthesia in operations involving the neck. The question of local or general anesthesia in goitre operations is not yet settled. The development of nitrous oxide anesthesia by Crile's school has done much towards making narcosis harmless and preferable where there is any question of mental shock under regional anesthesia. Leaving aside the mental element, local anesthesia has proved entirely adequate to a painless ligation of the thyroid arteries. In resections however there is one step that it is difficult to make painless, and that is the luxation of the goitre from its bed. Delivery of a goitre, especially if its capsule is adherent to the surrounding tissues, often involves pull on the

nerves beyond the limits of their blocking. If the patient manifests pain at this stage it is far better to stop the operation until he can be brought under a general anesthetic than to subject him to the physical and mental shock of further attempts under an insufficient regional anesthesia. Braun in a recent article on local anesthesia in major surgery has, however, described an improved method of local anesthesia for goitre in which he pays particular attention to subfascial injections, to the neighborhood of the goitre capsule and to the peritracheal tissues, this last in order to block the inferior laryngeal nerves. His experiences with goitre are interesting; in 1906 he operated 30 goitres, only 3 of them under local anesthesia; in 1907 he had 24 goitres, 15 with local anesthesia; in 1908 he had 28 goitres, one a substernal gland, and he operated all of them under a perfectly satisfactory local anesthesia. The class of patients from which he recruits his material does not differ materially from the class we have to do with here; the population of upper Saxony is of a rather nervous and vivacious temperament, very different to the phlegmatic Swiss with whom Kocher, the principal champion of local anesthesia for goitre operations, has to deal. Kocher's anesthesia (he uses the old infiltration method) is really little more than an anesthesia of the skin; little attempt is made to anesthetize the deep parts; I think that those who have seen him will concur with me that such a half-anesthesia would be utterly out of the question with our patients here. I have had no personal experience with the new technic for goitre that Braun describes, but should, on the weight of his authority, urge its trial in proper cases.

THE UPPER EXTREMITY.

There are two methods for anesthetizing the whole arm. In the first, described by Hirschel, the brachial plexus is blocked in the axilla; in the second, described by Kulenkampff, the plexus is reached in the inferior cervical triangle, in the space between scalenus and first rib.

Hirschel proceeds as follows: The arm is elevated and pressure made upon the axillary vessels by a compression pad applied well up under the pectoral muscle. This measure is to prevent the rapid absorption of the anesthetizing solution—whether it is necessary I cannot say, as I lack personal experience with this method. With the finger on the axillary artery as a guide a 2% solution of novocain plus adrenalin is injected into the axilla, the needle being directed in the axis of the humerus well up under the pectoral muscle, the solution being injected upwards for the median nerve, and anteriorly for the ulnar nerve; a third depot placed behind the artery blocks the radial nerve-trunk. Twenty to thirty cc. of solution are used; anesthesia is complete in 20 to 40 minutes and lasts 1½ hours. Hirschel cites three cases; a gunshot wound of the elbow, an amputation of the humerus, and a tuberculosis of the ulna; anesthesia was complete in all three.

Kulenkampff goes in directly above the middle of the clavicle, just to the outside of the subclavian artery, whose pulse is fixed by the fingers.

The needle is directed inwards and posteriorly, in a line which if projected backwards would cut the second or third dorsal spinous process. After traversing skin, superficial and deep fascia, he deposits 20 cc. of a 2% solution in the space between scalenus and first rib. A tingling sensation down the arm denotes that the plexus has been reached by the needle. Anesthesia is complete in about 15 minutes, if a 3% solution is used in 6-7, and lasts 1½ to 2 or 3 hours. The whole arm is anesthetic, with the exception of the outer deltoid region and the inner side of the humerus at the arm-pit. K. reports 25 cases, satisfactory anesthesia in 20, 3 needed the supplemental use of ether (these were the first trials). No untoward accidents.

Whereas these two methods of anesthetizing the whole arm necessitate care, and to my mind carry with them a certain element of risk owing to the proximity of the axillary vessels, the method already described by Braun of anesthetizing the hand has, I think, not received the attention it deserves. A small quantity of solution, 10 cc. of 2% novocain, suffices for anesthesia of the whole hand; the injection is simple and entirely without danger. The three nerves of the hand are anesthetized separately at different points, one nerve, combinations of two, or all three being anesthetized according to the site of the operation proposed. The ulnar is most conveniently reached at the inner condyle of the elbow, the radial is blocked above the wrist by an injection carried subcutaneously across the radial side of the back of the forearm, the median is also reached above the wrist. The needle being inserted at the ulnar side of the long palmar tendon is pushed *through the fascia* and then directed radially so that its point lies under the tendon of the radial flexor muscle. By injecting all three of these nerves with a few cc. of novocain plus adrenalin an anesthesia of the entire hand is obtained in from 10 to 15 minutes, which lasts for 1 to 2 hours. I think that regional anesthesia should entirely supplant general anesthesia for operations on the hand; with this method of nerve-blocking we need no longer fear the edematization of infected territory in operations on whitlows and felons, the bleeding is greatly lessened by the adrenalin injection, and the advantage in tendoplasties and complicated operations on the hand of having a patient who can move his muscles at a word from the operator is obvious.

As regards the plexus anesthetics of the arm, they *do* carry with them some risk of injury to the great vessels, a risk great enough perhaps to offset the unpleasantness of a general anesthetic. Still I think that a certain field of usefulness will remain for plexus anesthesia, not only in decrepit patients and others where a general anesthetic is contraindicated, but most particularly for the general and for the country practitioner, who alone and without assistance can secure a perfect anesthesia and a relaxed musculature that should prove invaluable to him in the treatment of fractures and dislocations, and in the emergency surgery of the upper extremity.

CHEST.

Hirschel has performed thoracoplasties and extensive operations for cancer of the breast under regional anesthesia. He first blocks the nerves in the axilla in the manner described above, adds a subcutaneous injection elliptically about the mamma, and finally blocks the intercostal nerves by depositing 2 or 3 cc. of novocain in each of the first four or five intercostal spaces, using the borders of the ribs as a guide. Regional anesthesia is contraindicated in adipose patients on account of the difficulty of determining the intercostal spaces when they are covered by too deep a layer of fat. Hirschel reports three operations for mammary cancer and two thoracoplasties, all of them with good anesthesia.

I have had occasion to use a procedure which may perhaps prove useful in certain cases of inoperable cancer of the breast. The patient was an old woman with an extensive Paget's disease, enclosing the whole side of the thorax like a cuirass. Pain had prevented her sleeping for many nights. I injected the 6 upper intercostal nerves, first with novocain-adrenalin, then with 1 cc. of 96% alcohol, choosing my site of injection in the back, a handsbreadth from the middle line. There was a sharp pain after each injection of alcohol, followed by numbness and relief which lasted about a week, so that after the injection the patient slept for the first time in weeks. In another case I should substitute osmic acid, acetone or chloroform for alcohol in order to make the degeneration of the nerves more permanent. The alcohol was evidently diluted in the tissues by the previous injection of novocain to a concentration which did not suffice to produce permanent degeneration of the nerves. The method is not difficult, I should be grateful for its repetition and trial by others.

ABDOMEN, HERNIA, GENITAL ORGANS, ANUS.

The last five years have not brought any fundamentally important advances in the local anesthesia of these regions. Suitable for local anesthesia are those abdominal operations where we may be sure of our procedure before opening the belly; gastrostomy for cardiac or esophageal obstruction, colostomy, the closure of simple fecal fistulas, and gastroenterostomy in certain cases of well-defined and uncomplicated pyloric obstruction may all be performed under regional anesthesia.

After a rhombic area of the skin about the site of the proposed incision has been blocked off, a liberal quantity of ½-1% novocain-adrenalin should be injected subfascially and peritonally; this latter point is most important in order to anesthetize the parietal peritoneum. If dragging upon or otherwise maltreating the mesenteric attachments of the viscera is avoided the operation will be entirely painless. Local anesthesia is unsuitable for any operation involving exploration of the viscera, even for appendectomy in the interval—we cannot determine the position of the appendix before entering the belly, and the delivery of an adherent, a retrocecal or a retroperitoneal appendix cannot be accomplished without unduly distressing the patient.

One of the most grateful operations for regional anesthesia is hernia. Small epigastric and umbilical hernias need no further allusion; large umbilical hernias requiring Mayo's operation call for general narcosis.

The technic for inguinal and femoral hernia is simple. The corners of a rhombic area are marked off by four intradermatic wheals, the first about two inches medial to, and one inch below the superior iliac spine; the second at the base of the scrotum; the third and fourth above and below the line joining these two points. The four wheals are connected by a subcutaneous injection; and a further deposit of novocain is made subfascially at the upper outer corner to block the ileo-hypogastric, the ileo-inguinal and the genito-femoral nerves; the whole mass of the cord and the neck of the hernial sack is then picked up in the inguinal canal with the fingers of the left hand, and 5 cc. of 2% novocain are injected subfascially at the head of the canal into the vicinity of the cord. Ileo-inguinal and spermatic nerves are blocked at this point and the whole contents of the scrotum made anesthetic. A similar technic is followed for operations on the testicle, varicocele and hydrocele. For femoral hernia point two is placed lower and more laterally, on the thigh; the technic is otherwise the same. Large hernias, necessitating the replacement of considerable amounts of viscera, and hernias in very adipose patients should be operated upon under a general anesthetic. Tying off the neck of the sack, if the ligature is placed high sometimes causes a momentary twinge of pain; the anesthesia is otherwise complete, takes about 10 minutes to induce and lasts 1½ hours. I can strongly recommend these methods. In clinics where local anesthesia is in use for hernias patients demand it in preference to a general anesthetic. Braun performed 119 operations for hernia in 1908, 72 of them under local anesthesia. The report of the surgical clinic in Heidelberg for 1910 gives 231 adult patients with inguinal hernias, all but 9 of them were operated upon under local anesthesia. Cushing's studies on local anesthesia in hernia made in 1900 were pioneers; the principles he laid down are the ones we follow to-day; he but lacked the one all-important detail of the addition of adrenalin to his anesthetizing solution. I do not know why his work has been so little regarded now that our methods are more perfect—one might say here that "the evil that men do lives after them"; it was Schleich's utterly insufficient infiltration anesthesia and his fantastic theories concerning the anesthetic properties of indifferent solutions that did the cause of local anesthesia an injury from which it will take many years for it to recover.

A further operation in this region that is suitable for local anesthesia is the sectio alta of the bladder. The space of Retzius should be thoroughly infiltrated with novocain; the bladder wall often needs a separate injection if its incision is to be painless. It is best anesthetized after having been laid bare.

Let me allude to a small detail of technic in anesthetizing the prepuce for circumcision. The

base of the inner leaf of the prepuce is innervated by fine filaments that pierce the tunica albuginea at the coronary sulcus; in order to anesthetize these properly the prepuce should be held tense and particular attention should be paid to the infiltration of the tough subepithelial tissue at its base, where it joins the glans; an insufficient anesthesia of the inner leaf often results from neglect of this detail. Braun uses a 2% solution, thus avoiding the edema produced by larger quantities of a weaker solution.

I have had little success with local anesthesia in operations for hemorrhoids; a complete relaxation of the sphincter is necessary for a thorough dilatation of the anus if the muscles are not to be torn instead of stretched. An anesthesia extensive enough to render this part of the operation painless is difficult to secure.

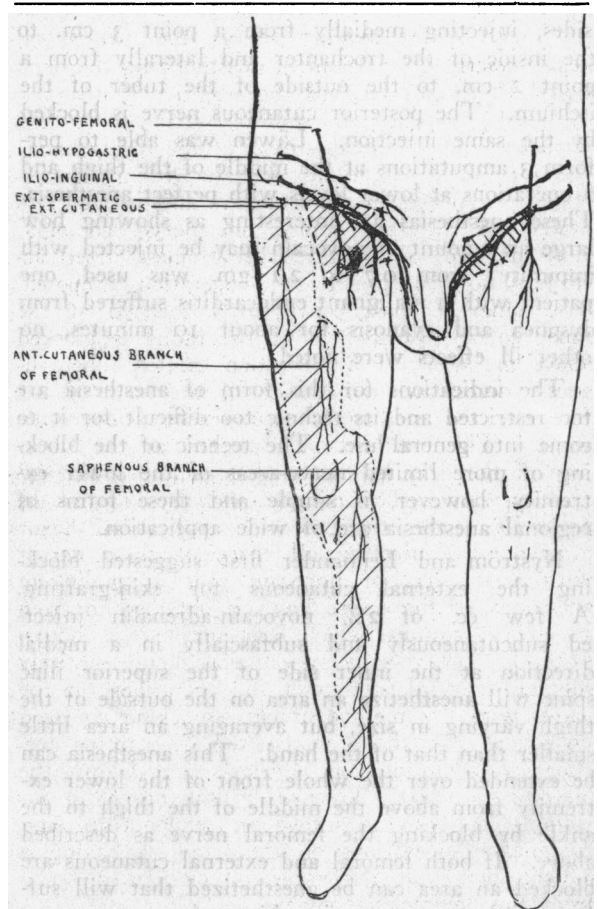


Fig. 2. Left side shows: (a) Sites of injection (marked by crosses), and area to be blocked off (shaded), for femoral hernia. (b) Area of anesthesia (shaded) for skin-grafting, obtained by blocking external cutaneous and femoral nerves.

Right side shows sites of injection and area to be blocked off for inguinal hernia.

LOWER EXTREMITY.

The innervation of the lower extremity is so complicated, the nerves reach the thigh at so many and at so widely separated points that an anesthesia of the whole thigh and leg is a matter of great difficulty. Its practical application will, I think, always be very limited. Læwen records 9 cases where he achieved this *tour de force*; he confined his trials to emaciated patients of weak

musculature. The femoral nerve was reached by a subfascial injection below Poupart's ligament 1-1½ cm. to the outside of the femoral artery, the external cutaneous was blocked by a subcutaneous and a subfascial injection below and just medial to the superior iliac spine, the cutaneous branches of the obturator were anesthetized by a deep injection into the inner aspect of the thigh near its middle; it was the blocking of the great sciatic that offered the main difficulty. Låwen injected 30 to 40 cc. of a 3 to 4% solution of his bicarbonate salt of novocain. The patient lying face downward, he first palpated the nerve in the gluteal fold, about midway between the tuber ossis ischii and the trochanter; the gluteal muscles being relaxed he could follow the nerve higher up, roll it beneath his fingers, and gain an opinion as to its depth. He approached the nerve with the needle from both the inner and the outer sides, injecting medially from a point 3 cm. to the inside of the trochanter and laterally from a point 2 cm. to the outside of the tuber of the ischium. The posterior cutaneous nerve is blocked by the same injection. Låwen was able to perform 3 amputations at the middle of the thigh and 6 operations at lower levels with perfect anesthesia. These anesthetics are interesting as showing how large an amount of novocain may be injected with impunity; from 0.7 to 2.1 gm. was used, one patient with a malignant endocarditis suffered from dyspnea and cyanosis for about 10 minutes, no other ill effects were noted.

The indications for this form of anesthesia are too restricted and its technic too difficult for it to come into general use. The technic of the blocking of more limited nerve-areas of the lower extremity, however, is simple and these forms of regional anesthesia are of wide application.

Nyström and Lennander first suggested blocking the external cutaneous for skin-grafting. A few cc. of 2% novocain-adrenalin injected subcutaneously and subfascially in a medial direction at the inner side of the superior iliac spine will anesthetize an area on the outside of the thigh varying in size, but averaging an area little smaller than that of the hand. This anesthesia can be extended over the whole front of the lower extremity from above the middle of the thigh to the ankle by blocking the femoral nerve as described above. If both femoral and external cutaneous are blocked an area can be anesthetized that will suffice for the most extensive skin-graft.

I can strongly recommend injections of weak novocain-adrenalin solutions (½-¾%) directly along the course of the veins for varicotomy. The anesthesia is complete, the bleeding is lessened by the adrenalin, and the extirpation of the varicosities is made particularly easy by the perivascular edema consequent to the injection of large quantities of weak anesthetic solutions.

Local anesthesia in the leg is a much simpler matter than in the thigh; the leg and foot are innervated entirely from three main branches—the saphenous branch of the femoral, the tibial and peroneal branches of the sciatic nerve. The saphenous may be blocked by a subcutaneous in-

jection beginning at the tuberosity of the tibia and extending medially and backwards across the tendon of the semitendinosus to the popliteal space. The tibial nerve is best reached farther down, before it divides into the medial and lateral plantar nerves at the level of the internal malleolus. The needle is inserted 1 cm. to the inside of the Achilles tendon and is pushed forward until it strikes the bone, it is then withdrawn slightly and a few cc. of 2% novocain-adrenalin injected. This one injection suffices to anesthetize the whole sole of the foot; if we add a subcutaneous injection circularly around the ankle, and one into the first intermetatarsal space, which blocks the deep peroneal, we get an anesthesia of the entire foot. This anesthesia of the foot and leg is not new, it is recorded by Braun in his book, but I take the liberty of calling it to your attention because I feel that its ease and simplicity entitle it to an application wider than that which it has received.

MISCELLANEOUS.

Lerda of Turin first called attention to the use of local anesthesia in recent fractures. With a stout needle he thoroughly infiltrates the periosteum and the soft tissues at the site of fracture; he reports some 30 cases and finds that in 10 to 15 minutes the spasm of the muscles involved by the fracture ceases, reduction of deformity is then painless and easy. This method was afterwards recommended by Quénu and extended by him to the treatment of dislocations. Quénu infiltrated the ligaments, the periarticular tissues and introduced the anesthetic solution into the joint-cavity itself; he found that dislocations of some standing were easily and painlessly reduced. I have had no experience with this application of local anesthesia. The anesthetizing of fractures would seem to me to be of value, particularly to the general practitioner, who would be able to work without the assistance of an anesthetist; the introduction of considerable quantities of an anesthetic drug into joint-cavities however, would seem to me to carry with it some little risk of too great an absorption and would make me hesitate to apply Quénu's procedure in dislocations.

Falkenstein has recently recommended periarticular injections of eusemin (a proprietary cocain-adrenalin mixture) in acute attacks of gout for prompt relief of pain.

A consideration of Bier's venous anesthesia, and of Cathelin's sacral epidural injections scarcely falls within the limits of this paper.

In the effort to make this map of the territory gained for local anesthesia since 1907 as complete as possible, even though I have had to confine myself to merely sketching in contours, I feel that I have already trespassed too considerably upon your attention to allow of further consideration of the general status of local anesthesia, its indications and contraindications. A word as to the preparation of the patients—I have usually given 0.3-0.5 gm. of veronal, to be taken on the tongue late the night before operation. Morphia should always be given, and the addition of a small amount of scopolamin is of advantage, particularly with aged and decrepit patients, upon whom scopolamin

seems to have an especially good soporific action and who stand the drug well. I usually give 0.0003 gm. scopolamin hydrobromide and 0.01 gm. morphin sulphate hypodermically one and one-half hours before operation, repeat the dose in one-half hour, then if the patient is not asleep give a third dose of 0.0003 gm. scopolamin alone without the morphin one-half hour before the operation. This is, you see, a small dose, 6 to 9 tenths of one milligramme of scopolamin in all. If the slightest suspicion as to the adequacy of the proposed local anesthesia exists, the patient should be prepared for a general anesthetic.

The operator should explain to the patient before beginning the anesthesia that he will feel the pain of the first pin-pricks but nothing more, and he should most particularly request the patient to let him know directly he feels any pain, explaining that he does not want him to suffer in silence but that, on the contrary, he would be interested in knowing whether and where pain is felt. Before beginning the incision he should assure himself of the completeness of the anesthesia by pricking the skin and inquiring as to sensibility. The patient should not know when the incision has been begun. Once pain is felt, STOP! Either complete the anesthesia by further injections of novocain or go over to general anesthesia. There is no sight more harrowing than that of an operator fighting his way to the end of an operation under an insufficient anesthesia, with a frightened, squirming patient whose consciousness is there, but whose confidence is gone.

Local anesthesia is contraindicated in children and in patients not amenable to reason; it should not be forced upon unwilling subjects nor tried when there is any reasonable probability of failure.

As to other objections: local anesthesia does not admit of hurried operating, nor of any but gentle and careful handling of tissues, any violence or dragging upon the nerves causes pain; whether these objections are points in its favor I leave it to you to say.

TO CONCLUDE:

(1) Extensive operations involving the mouth, the tongue, the jaws and the lips in mentally normal adult patients should be performed under regional anesthesia.

(2) The hand and foot may be easily and simply anesthetized; operations on these members should be performed under regional anesthesia.

(3) Skin is easily and simply grafted under regional anesthesia, which is the anesthesia of choice.

(4) Many extensive operations on the chest, abdomen and extremities may be performed under regional anesthesia.

(5) Injection of the intercostal nerves with osmic acid or similar substances may be of use in certain cases of inoperable cancer of the breast.

(6) The trial of local anesthesia in reducing deformity is urged in certain cases of fracture; this may prove especially valuable to the general practitioner.

(7) Novocain is the drug of choice; it should supplant cocain in regional anesthesia.

(8) The infiltration anesthesia of Schleich is to be abandoned as entirely inadequate in the great majority of cases; for it is to be substituted regional anesthesia as developed by Cushing, Crile, Hackenbruch, Matas and especially Braun.

(9) Local anesthesia should not be forced upon unwilling patients; its use should not be tried in unsuitable cases; its limitations should be strictly observed.

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ANESTHETICS, METHODS AND INDICATIONS.*

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The practice of employing but one anesthetic or one mode of administration for all cases has gone by; in this paper I will discuss the special indications for individual anesthetics, sequences and methods. I will confine my attention to four fundamental substances: Nitrous oxide, Ether, Chloroform, Ethyl Chloride, and to sequences of the same.

In determining the selection for any case, the most important consideration is the *safety of the patient*. Two questions present themselves: (1) Which is the safest anesthetic for brief operations, and those not requiring total muscular relaxation?

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